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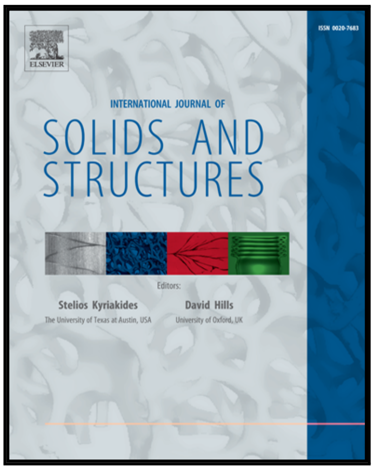

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Fracture Mechanics Analysis of Size-dependent Piezoelectric Solids

Jan Sladek [1], Vladimir Sladek [1], Peter Stanak[1], Chuanzeng Zhang[2], Choon-Lai Tan[3]

[1] Institute of Construction and Architecture, Slovak Academy of Sciences, 84503 Bratislava, Slovakia, telephone/fax number: +421-54773548, e-mail: jan.sladek@savba.sk
[2] Department of Civil Engineering, University of Siegen, D-57068 Siegen, Germany
[3]Department of Mechanical & Aerospace Engineering, Carleton University, Ottawa, Canada K1S 5B6

Abstract

The finite element method (FEM) is developed to analyze general 2D boundary value problems in size-dependent piezoelectric, elastic solids with cracks. The size-effect phenomenon in micro/nano electronic structures is described by the strain-gradient effect. The electric field-strain gradient coupling is considered in the constitutive equations of the material and the governing equations are derived with the corresponding boundary conditions using the variational principle. The FEM formulation is subsequently developed and implemented for strain-gradient piezoelectricity. The path-independent *J*-integral is also derived for fracture mechanics analysis of such solids. Numerical examples are presented to demonstrate the vericity of the formulations.

Keyword: finite element method, gradient theory, flexoelectricity, in-plane crack problems

1. Introduction

Advances in technology have resulted in the development of small microelectronic components and devices. In classical piezoelectricity, the relation between electric polarization and strain in non-centrosymmetric dielectrics is defined at the macro-scale (Cady, 1964). A number of experiments have shown, however, a size-effect phenomenon of piezoelectric solids and linear electromechanical coupling in isotropic materials (Shvartsman et al., 2002; Buhlmann et al., 2002; Cross, 2006; Harden et al., 2006; Zhu et al., 2006; Baskaran et al., 2011; Catalan et al., 2011). They occur when the dimensions of the component are comparable to the material length scale. It is also well-known that classical continuum mechanics neglects the interaction of material microstructure and the results are size-independent. Thus, it is necessary to employ a more appropriate and reliable size-dependent theory of piezoelectricity in which higher gradients of deformation are considered. Wang et al. (2004) have developed a size-dependent